

## *Stabilize drainage ways*

### **Check Dams**

#### **Construction Site Storm Water Runoff Control**

##### **Description**

Check dams are small, temporary dams constructed across a swale or channel. Check dams can be constructed using gravel, rock, sandbags, logs, or straw bales and are used to slow the velocity of concentrated flow in a channel. By reducing the velocity of the water flowing through a swale or channel, check dams reduce the erosion in the swale or channel. As a secondary function, check dams can also be used to catch sediment from the channel itself or from the contributing drainage area as storm water runoff flows through the structure. However, the use of check dams in a channel should not be a substitute for the use of other sediment-trapping and erosion control measures. As with most other temporary structures, check dams are most effective when used in combination with other storm water and erosion and sediment control measures.



##### **Applicability**

Check dams should be used in swales or channels that will be used for a short period of time where it is not practical to line the channel or implement other flow control practices (USEPA, 1993). In addition, check dams are appropriate where temporary seeding has been recently implemented but has not had time to take root and fully develop. Check dams are usually used in small open channels with a contributing drainage area of 2 to 10 acres. For a given swale or channel, multiple check dams, spaced at appropriate intervals, can increase overall effectiveness. If dams are used in a series, they should be spaced such that the base of the upstream dam is at the same elevation as the top of the next downstream dam (VDCR, 1995).

##### **Siting and Design Considerations**

Check dams can be constructed from a number of different materials. Most commonly, they are made of rock, logs, sandbags, or straw bales. When using rock or stone, the material diameter should be 2 to 15 inches. Logs should have a diameter of 6 to 8 inches. Regardless of the material used, careful construction of a check dam is necessary to ensure its effectiveness. Dams should be installed with careful placement of the construction material. Mere dumping of the dam material into a channel is not appropriate and will reduce overall effectiveness.

All check dams should have a maximum height of 3 feet. The center of the dam should be at least 6 inches lower than the edges. This design creates a weir effect that helps to channel flows away from

the banks and prevent further erosion. Additional stability can be achieved by implanting the dam material approximately 6 inches into the sides and bottom of the channel (VDCR, 1995). When installing more than one check dam in a channel, outlet stabilization measures should be installed below the final dam in the series. Because this area is likely to be vulnerable to further erosion, riprap, geotextile lining, or some other stabilization measure is highly recommended.

### **Limitations**

Check dams should not be used in live, flowing streams unless approved by an appropriate regulatory agency (USEPA, 1992; VDCR, 1995). Because the primary function of check dams is to slow runoff in a channel, they should not be used as a stand-alone substitute for other sediment-trapping devices. Also, leaves have been shown to be a significant problem by clogging check dams in the fall. Therefore, they might necessitate increased inspection and maintenance.

### **Maintenance Considerations**

Check dams should be inspected after each storm event to ensure continued effectiveness. During inspection, large debris, trash, and leaves should be removed. The center of a check dam should always be lower than its edges. If erosion or heavy flows cause the edges of a dam to fall to a height equal to or below the height of the center, repairs should be made immediately. Accumulated sediment should be removed from the upstream side of a check dam when the sediment has reached a height of approximately one-half the original height of the dam (measured at the center). In addition, all accumulated sediment should also be removed prior to removing a check dam. Removal of a check dam should be completed only after the contributing drainage area has been completely stabilized. Permanent vegetation should replace areas from which gravel, stone, logs, or other material have been removed. If the check dam is constructed of rock or gravel, maintenance crews should be sure to clear all small rock and gravel pieces from vegetated areas before attempting to mow the grass between check dams. Failure to remove stones and gravel can result in serious injury from flying debris.

### **Effectiveness**

Field experience has shown that rock check dams are more effective than silt fences or straw bales to stabilize wet-weather ditches (VDCR, 1995). For long channels, check dams are most effective when used in a series, creating multiple barriers to sediment-laden runoff.

### **Cost Considerations**

The cost of check dams varies based on the material used for construction and the width of the channel to be dammed. In general, it is estimated that check dams constructed of rock cost about \$100 per dam (USEPA, 1992). Other materials, such as logs and sandbags, may be less expensive, but they might require higher maintenance costs.

## References

USEPA. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA 840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1992. *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices*. EPA 832-R-92-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

VDCR. 1995. *Virginia Erosion & Sediment Control Field Manual*. Second Edition. Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond, VA.

Washington State Department of Ecology. 1992. *Stormwater Management Manual for the Puget Sound Basin*. Technical manual. Washington State Department of Ecology, Olympia, WA.

## **Filter Berms**

### **Construction Site Storm Water Runoff Control**

#### **Description**

A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone, or crushed rock that slows, filters, and diverts flow from an open traffic area and acts as an efficient form of sediment control. A specific type of filter berm is the continuous berm, a geosynthetic fabric that encapsulates sand, rock, or soil.

#### **Applicability**

Gravel or stone filter berms are most suitable in areas where vehicular traffic needs to be rerouted because roads are under construction, or in traffic areas within a construction site.

#### **Siting and Design Considerations**

The following construction guidelines should be considered when building the berm:

- Well-graded gravel or crushed rock should be used to build the berm.
- Berms should be spaced according to the steepness of the slope, with berms spaced closer together as the slope increases.
- Sediment that builds up should be removed and disposed of and the filter material should be replaced. Regular inspection should indicate the frequency of sediment removal needed.

#### **Limitations**

Berms are intended to be used only in gently sloping areas. They do not last very long, and they require maintenance due to clogging from mud and soil on vehicle tires.

#### **Maintenance Considerations**

The berm should be inspected after every rainfall to ensure that sediment has not built up and that no damage has been done by vehicles. It is important that repairs be performed at the first sign of deterioration to ensure that the berm is functioning properly.

#### **Effectiveness**

The effectiveness of a rock filter berm depends upon rock size, slope, soil, and rainfall amount. The continuous berm is not staked into the ground and no trenching is required. Effectiveness has been rated at up to 95 percent for sediment removal, but is highly dependent on local conditions including hydrologic, hydraulic, topographic, and sediment characteristics.

## **Cost Considerations**

Construction materials for filter berms (mainly gravel) are relatively low cost, but installation and regular cleaning and maintenance can result in substantial labor costs. These maintenance costs are lower in areas of less traffic, gentler slopes, and low rainfall.

## **References**

Fifield, S.J. 1997. *Field Manual for Effective Sediment and Erosion Control Methods*. Hydrodynamics, Inc., Parker, CO.

USEPA. 1992. Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices. EPA 832-R-92-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

## Grass-Lined Channels

### Construction Site Storm Water Runoff Control

#### Description

Grass-lined channels convey storm water runoff through a stable conduit. Vegetation lining the channel reduces the flow velocity of concentrated runoff. Grassed channels usually are not designed to control peak runoff loads by themselves and are often used in combination with other BMPs, such as subsurface drains and riprap stabilization. Where moderately steep slopes require drainage, grassed channels can include excavated depressions or check dams to enhance runoff storage, decrease flow rates, and enhance pollutant removal. Peak discharges can be reduced through temporary detention in the channel. Pollutants can be removed from storm water by filtration through vegetation, by deposition, or in some cases by infiltration of soluble nutrients into the soil. The degree of pollutant removal in a channel depends on the residence time of water in the channel and the amount of contact with vegetation and the soil surface. As a result, removal efficiency is highly dependent on local conditions.



**A grass-lined channel can be used to filter and convey runoff**

#### Applicability

Grassed channels should be used in areas where erosion-resistant conveyances are needed, including areas with highly erodible soils and moderately steep slopes (although less than 5 percent). They should only be installed where space is available for a relatively large cross section. Grassed channels have a limited ability to control runoff from large storms and should not be used in areas where flow rates exceed 5 feet per second.

#### Siting and Design Considerations

Grass-lined channels should be sited in accordance with the natural drainage system and should not cross ridges. The channel design should not have sharp curves or significant changes in slope. The channel should not receive direct sedimentation from disturbed areas and should be sited only on the perimeter of a construction site to convey relatively clean storm water runoff. Channels should be separated from disturbed areas by a vegetated buffer or other BMP to reduce sediment loads.

Basic design recommendations for grassed channels include the following:

- Construction and vegetation of the channel should occur before grading and paving activities begin.
- Design velocities should be less than 5 feet per second.

- Geotextiles can be used to stabilize vegetation until it is fully established.
- Covering the bare soil with sod, mulches with netting, or geotextiles can provide reinforced storm water conveyance immediately.
- Triangular-shaped channels are used with low velocities and small quantities of runoff; parabolic grass channels are used for larger flows and where space is available; trapezoidal channels are used with large flows of low velocity (low slope).
- Outlet stabilization structures should be installed if the runoff volume or velocity has the potential to exceed the capacity of the receiving area.
- Channels should be designed to convey runoff from a 10-year storm without erosion.
- The sides of the channel should be sloped less than 2:1, and triangular-shaped channels along roads should be sloped 2:1 or less for safety.
- All trees, brushes, stumps, and other debris should be removed during construction.

### **Effectiveness**

Grass-lined channels can effectively transport storm water from construction areas if they are designed for expected flow rates and velocities and if they do not receive sediment directly from disturbed areas.

### **Limitations**

Grassed channels, if improperly installed, can alter the natural flow of surface water and have adverse impacts on downstream waters. Additionally, if the design capacity is exceeded by a large storm event, the vegetation might not be sufficient to prevent erosion and the channel might be destroyed. Clogging with sediment and debris reduces the effectiveness of grass-lined channels for storm water conveyance.

### **Maintenance Considerations**

Maintenance requirements for grass channels are relatively minimal. During the vegetation establishment period, the channels should be inspected after every rainfall. Other maintenance activities that should be carried out after vegetation is established are mowing, litter removal, and spot vegetation repair. The most important objective in the maintenance of grassed channels is the maintaining of a dense and vigorous growth of turf. Periodic cleaning of vegetation and soil buildup in curb cuts is required so that water flow into the channel is unobstructed. During the growing season, channel grass should be cut no shorter than the level of design flow.

### **Cost Considerations**

Costs of grassed channels range according to depth, with a 1.5-foot-deep, 10-foot-wide grassed channel estimated between \$6,395 and \$17,075 per trench, while a 3.0-foot-deep, 21-foot-wide grassed channel is estimated at \$12,909 to \$33,404 per trench (SWRPC, 1991). Grassed channels can be left in place permanently after the construction site is stabilized to contribute to long-term storm water management. The channels, in combination with other practices that detain, filter, and

infiltrate runoff, can substantially reduce the size of permanent detention facilities such as storm water ponds and wetlands, thereby reducing the overall cost of storm water management.

## References

FHWA. 1995. *Best Management Practices for Erosion and Sediment Control*. FHWA-SLP-94-005. Federal Highway Administration, Sterling, VA.

MPCA. 1998. *Protecting Water Quality in Urban Areas*. Minnesota Pollution Control Agency, Division of Water Quality, St. Paul, MN.

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

SWRPC. 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Technical Report No. 31. Southeast Wisconsin Regional Planning Commission, Waukesha, WI.



## Riprap

### Construction Site Storm Water Runoff Control

#### Description

Riprap is a permanent, erosion-resistant layer made of stones. It is intended to protect soil from erosion in areas of concentrated runoff. Riprap may also be used to stabilize slopes that are unstable because of seepage problems.

#### Applicability

Riprap can be used to stabilize cut-and-fill slopes; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and streambanks and grades.

#### Siting and Design Considerations

Riprap may be unstable on very steep slopes, especially when rounded rock is used. For slopes steeper than 2:1, consider using materials other than riprap for erosion protection. If riprap is being planned for the bottom of a permanently flowing channel, the bottom can be modified to enhance fish habitat. This can be done by constructing riffles and pools which simulate natural conditions. These riffles promote aeration and the pools provide deep waters for habitats.

The following are some design recommendations for riprap installation, (Smolen et al., 1988):

- *Gradation.* A well-graded mixture of rock sizes should be used instead of one uniform size.
- *Quality of stone.* Riprap must be durable so that freeze/thaw cycles do not decompose it in a short time; most igneous stones such as granite have suitable durability.
- *Riprap depth.* The thickness of riprap layers should be at least 2 times the maximum stone diameter.
- *Filter material.* Filter material is usually required between riprap and the underlying soil surface to prevent soil from moving through the riprap; a filter cloth material or a layer of gravel is usually used for the filter.
- *Leaching Protection.* Leaching can be controlled by installing a riprap gradation small enough to act as a filter against the channel base material, or a protective filter can be installed between the riprap and the base material.
- *Riprap Limits.* The riprap should extend for the maximum flow depth, or to a point where vegetation will be satisfactory to control erosion.



Riprap can be used to stabilize drainageways and outlets to prevent erosion

- *Curves.* Riprap should extend to five times the bottom width upstream and downstream of the beginning and ending of the curve as well as the entire curved section.
- *Riprap Size.* The size of riprap to be installed depends on site-specific conditions.

### **Limitations**

Riprap is limited by steepness of slope, because slopes greater than 2:1 have potential riprap loss due to erosion and sliding. When working within flowing streams, measures should be taken to prevent excessive turbidity and erosion during construction. Bypassing base flows or temporarily blocking base flows are two possible methods.

### **Effectiveness**

When properly designed and installed, riprap can prevent virtually all erosion from the protected area.

### **Maintenance Considerations**

Riprap should be inspected annually and after major storms. If riprap has been damaged, repairs should be made promptly to prevent a progressive failure. If repairs are needed repeatedly at one location, the site should be evaluated to determine if the original design conditions have changed. Channel obstructions such as trees and sediment bars can change flow patterns and cause erosive forces that may damage riprap. Control of weed and brush growth may be needed in some locations.

### **Cost Considerations**

The cost of riprap varies depending on location and the type of material selected. A cost of \$35 to \$50 per square yard of nongrouted riprap has been reported, while grouted riprap ranges from \$45 to \$60 per square yard (1993 dollars; Mayo et al., 1993). Alternatives to riprap channel lining include grass, sod, and concrete, which cost \$3, \$7, \$8, \$12, and \$25 to \$30 per square yard, respectively (1993 dollars, Mayo et al., 1993).

### **References**

- FHWA. 1995. *Best Management Practices for Erosion and Sediment Control*. FHWA-SLP-94-005. Federal Highway Administration, Sterling, VA.
- Mayo, L., D. Lehman, L. Olinger, B. Donovan, and P. Mangarella. 1993. *Urban BMP Cost and Effectiveness Summary Data for 6217(g) Guidance: Erosion and Sediment Control During Construction*. Woodward-Clyde Consultants.
- MPCA. 1998. *Protecting Water Quality in Urban Areas*. Minnesota Pollution Control Agency, Division of Water Quality, St. Paul, MN.
- Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.
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